PROPRIOCEPTIVE CONTROL OF A HABIT

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INTRODUCTION

Psychologists have long been interested in the role played by movement-produced cues. Yet, in spite of the emphasis given to proprioception by such theorists as Watson (3) and Guthrie (2), there have been relatively few attempts to make use of this sensory mode in research on human conditioning. Previous work in the area includes a study by L. H. Beck (1) in which the effect of a regularly recurrent series of hand movements on eyelid conditioning was investigated. In Beck's experiment a click acted as CS and a shock to the infraorbital foramen was used as US. He found that conditioning did not occur unless the massed once-per-second trials were accompanied by a previously organized movement cycle. This organized cycle was obtained by giving the subjects pre-training practice in tapping in time to the click until they would continue to tap at least once when the click was omitted. When the organized cycle was present, conditioned responses would usually be elicited after the first trial. On the other hand, subjects who did not get tapping practice prior to acquisition trials but began tapping only during acquisition did not condition in fifty trials.

It was also found that the conditioned responses tended to cluster very steeply around the beat stroke of the tapping cycle. When Beck varied the interval between click and shock, he found that the CR's distributed themselves around the beat stroke no matter what the temporal position of the shock was. Thus the proprioceptive feedback from one particular phase of the movement cycle seemed to become the crucial eliciting cue for the CR's.

The purpose of the experiment reported here was two-fold. First, it was considered necessary to replicate Beck's experimental conditions with additional controls. Secondly, we wished to extend the scope of the earlier investigation by varying such parameters as the source of the proprioception and the time interval between the proprioceptive cue elements , and the external CS and US.

APPARATUS AND PROCEDURE

Apparatus.-- Polygraph records of the stimulus-response sequence were made on electrically sensitive paper. The subject was seated in front of a table with his head supported by a chin rest. A webbed belt held the head in position against a metal frame. On the table a small buzzer was placed 7 inches in front of the subject. Buzzer action was recorded on the polygraph by a magnetic pointer. Manual response was recorded by placing the index finger of the right hand in a glove finger connected to a mechanical pointer by a string and pully arrangement. A light aluminum lever was attached to the upper lid of the left eye with a small piece

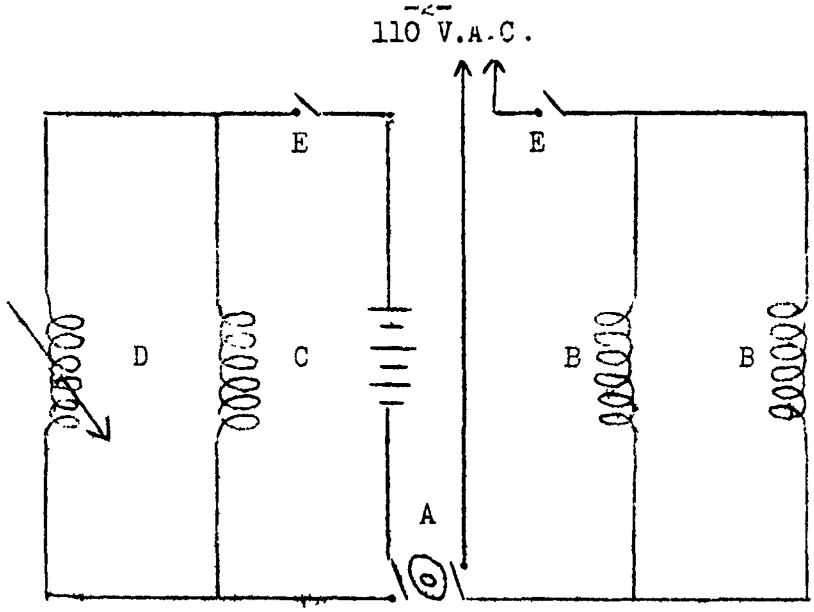

Fig. 1. A schematic diagram of the buzzer and air-puff circuits. Shown are (A) timer cam and microswitches, (B) puff solenoids in parallel, (C) buzzer, (D) magnetic pointer and (E) manual control switches. The functioning of the apparatus is described in the text.

of adhesive tape. An eyeblink moved the lever upward against an electrical contact, thus closing a circuit which activated a magnetic polygraph pointer. The contact was adjusted so that a normal eye blink just closed it. An air puff was delivered to the cornea of the left eye through a small glass nozzle approximately ½ inch in front of the eye. The source of the puff was a metal cylinder equipped with a solenoid activated piston. A second such arrangement delivered a simultaneous air puff to the rubber diaphragm of a pneumatic polygraph pointer. Activation of the buzzer and air puff circuits was controlled by two microswitches closed in a fixed time sequence by a motor-driven cam. The polygraph, puff mechanism, timer and control switches were all located in a separate room adjacent to the one containing the subject. The walls of both rooms were made sound resistant with acoustical celotex. An intercom system enabled the subjects to communicate with the experimenter.

Subjects.-- Forty graduate and undergraduate students at the University of Connecticut served as subjects. All were volunteers who were paid for their services.

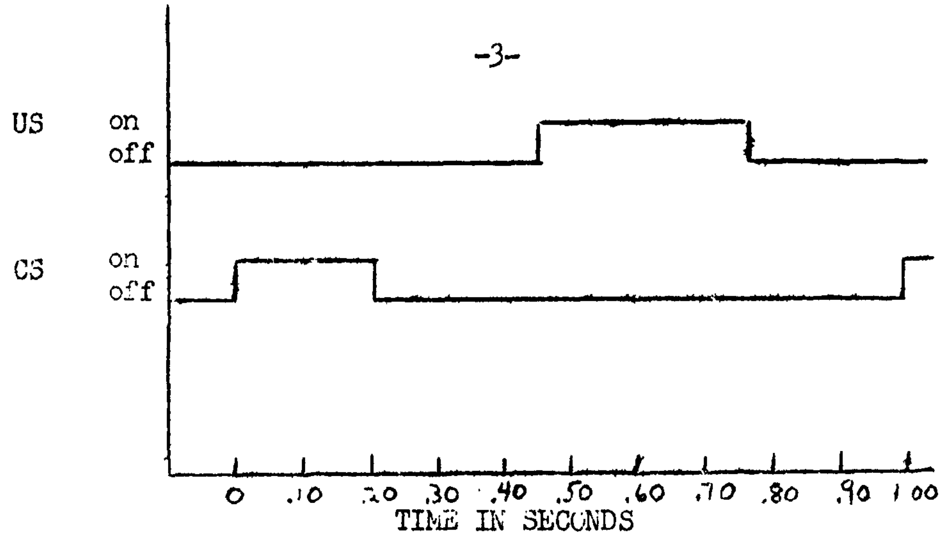

Fig. 2. The time sequence of a typical trial. The important time relationships are: buzzer duration: .20 seconds, puff duration: .33 seconds, interval between buzzer onset and puff onset: .45 seconds.

<u>Procedure</u>.— <u>A. Pre-tap group</u>. Fourteen S's received 90 seconds of practice in tapping to a once-per-second buzzer. The subjects were instructed to tap so that their index finger struck the table just as the buzzer went off. The buzzer was periodically omitted as a test of movement cycle organization. All subjects in this group demonstrated an organized movement cycle by the end of the allotted 90 seconds. Following the tapping practice, 53 acquisition trials were administered in 3 blocks with an average of 11 trials occurring on the first run and 21 trials occurring on the two succeeding runs. There was some individual variation in the exact size of the trial blocks. However, 80 per cent of the trial blocks were within one trial of the 11-21-21 averages. The interval between trial blocks was approximately 12 seconds. The subjects continued to tap to the buzzer (now the external CS) during both acquisition and extinction. At the beginning of each trial block the buzzer was sounded twice without the puff in order to allow the subjects to resume the tapping cycle. The time sequence of a single trial (CS-US pairing) is shown in Fig. 2. Twenty extinction trials followed the last acquisition trial after a 12 second interval. An extinction trial consisted of a presentation of the buzzer without the puff.

<u>B. Tap-group</u>. The sequence of trials given to the tap group was exactly the same as described for the pre-tap group except for the omission of the pre-trial practice in tapping. Therefore, this group was given no opportunity to establish a movement cycle prior to acquisition. The 13 S's were instructed to begin tapping as soon as they heard the buzzer at the beginning of the first run of trials.

C. No-tap group. Thirteen S's in this group received the same order of acquisition and extinction trials as the previously described groups. However, these subjects were not required to tap at any time during the experiment. The results obtained with this group would indicate the amount of conditioning occurring in the absence of any experimentally induced proprioceptive pattern, thereby providing a control not present in Beck's study.

All blinking responses which took place during the puff were called unconditioned responses, all other responses were classified as conditioned responses. All responses occurring during extinction were regarded as CR's. See Fig. 3 for a typical response record.

RESULTS

Our results do not confirm Beck's conclusion that no conditioning takes place unless there is prior organization of a movement cycle.

TABLE 1

PERCENTAGE OF ACQUISITION TRIALS

ON WHICH CONDITIONED RESPONSES OCCURRED

	Group		
	Tap	Pre-tap	No tap
Mean	42.9	39.3	32.3
Median	40.0	35.9	25.0

As seen in table 1 conditioning was obtained in all three groups. None of the differences among the means reached the P = .10 level of significance. Evidence for the importance of the proprioceptive feed-back appearsin the learning curves of the three groups (Fig. 4). The progressive diminution of no-tap response strength is obvious. As seen in table 2 all the groups show extremely rapid learning on the first block of trials but the presence of the tapping cycle seems necessary to sustain the level of conditioning throughout training.

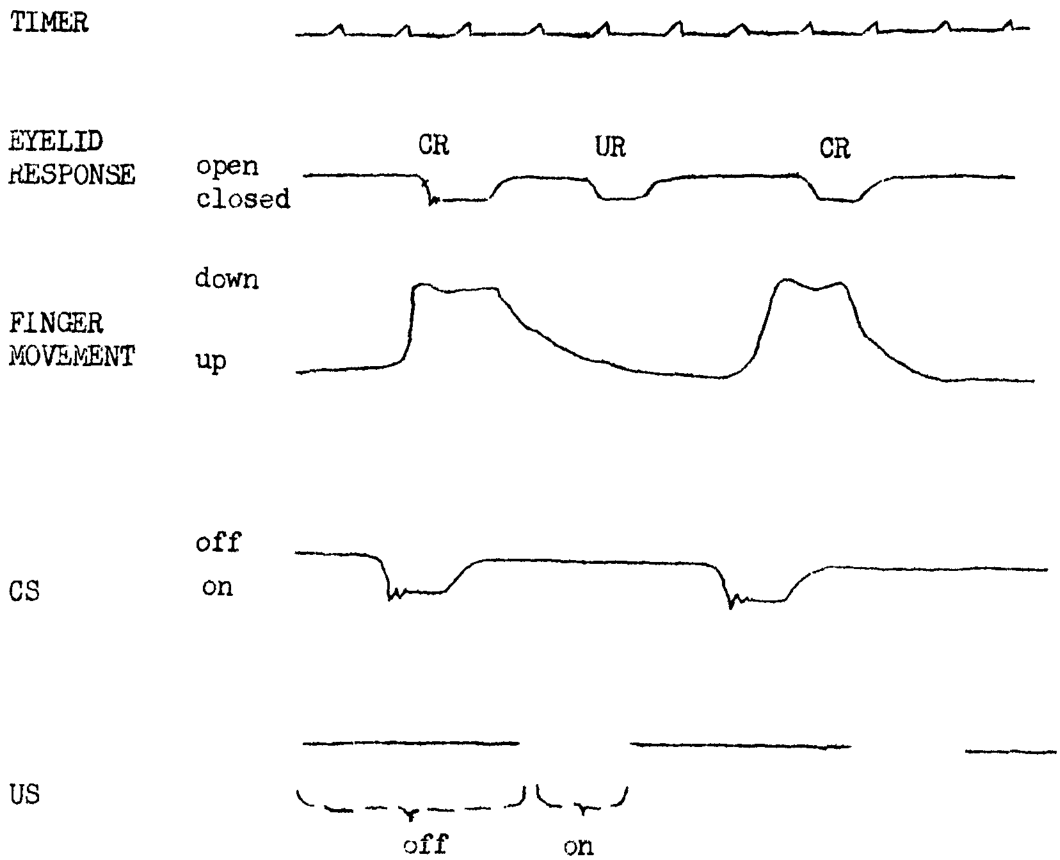

Fig. 3. A tracing of a typical polygraph record. Note the 2 CRs in close temporal contiguity with the beat stroke of the tapping cycle. The nibs on the timer line are .2 seconds apart.

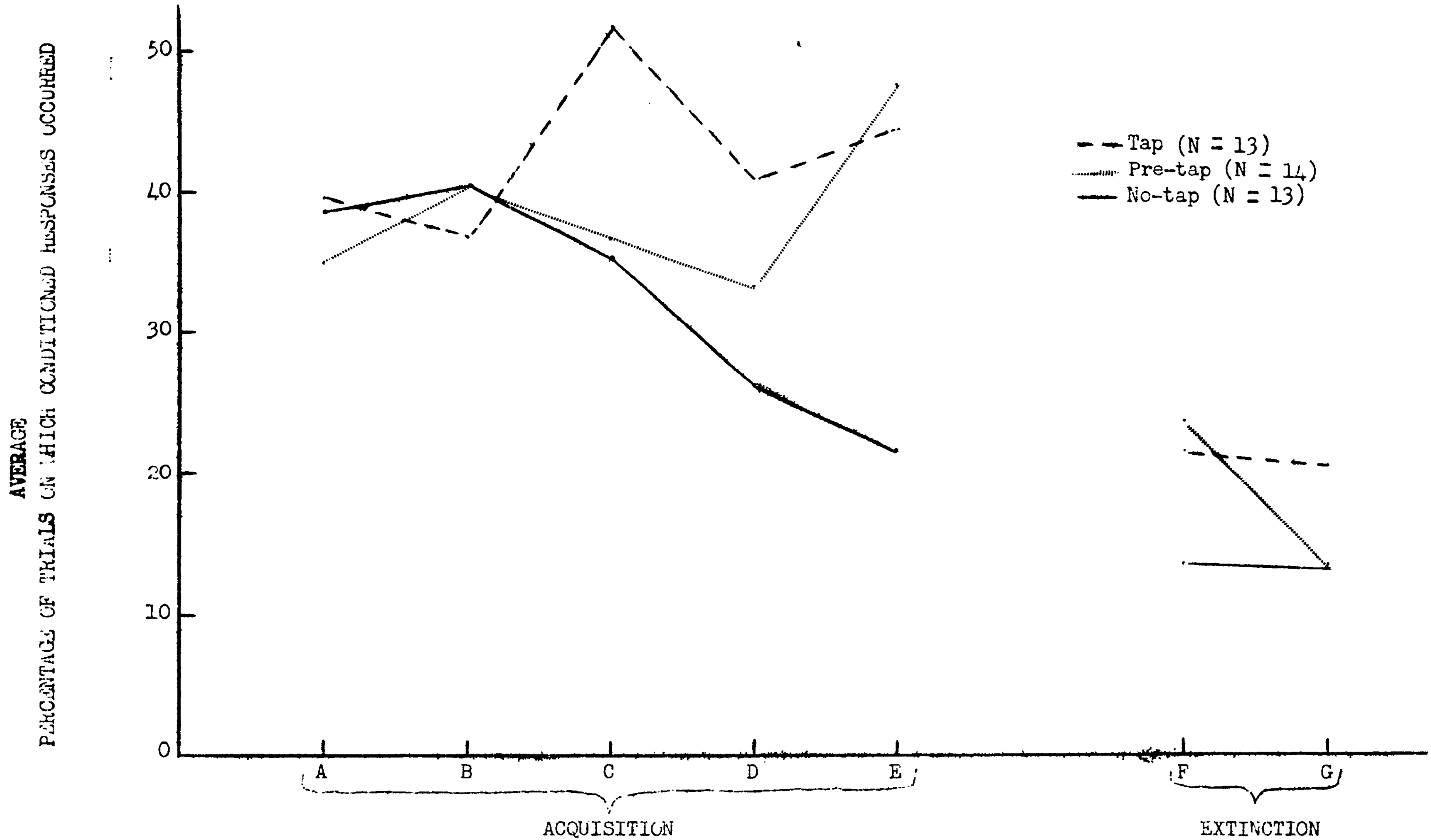

Fig. 4. Learning curves of the three groups. The second and third blocks of acquisition trials and the extinction sequence have each been divided into 2 series of approximately 10 trials each.

TABLE 2

FIRST APPEARANCE OF CONDITIONED RESPONSE

		Group		
		Tap	Pre-tap	No-tap
Trial	2	3	7	9
	3	4	3	2
	4		1	
	5	4	1	1
	6		1	
	7	1		
	8		1	
	9 and up	1		1
Total Subjects		13	14	13
Median Trial		3	2.5	2

The figures represent the number of subjects demonstrating an initial CR.

Beck's finding that the learning exhibits weak resistence to extinction was replicated in all three groups.

Another demonstration of the influence of the proprioceptive cue pattern is provided by Fig. 5. There is a conspicuous coordination of the conditioned responses of both the tap and pre-tap groups with the beat-stroke of the tapping cycle.

In view of Beck's conclusion that an organized movement cycle is a necessary condition for establishing proprioceptive control of the eyeblink habit, the tap group's stability of learning and clustering of conditioned response around the beat stroke are surprising. An explanation may be found in the fact that this group appears to have been able to organize a movement cycle during acquisition. Evidence

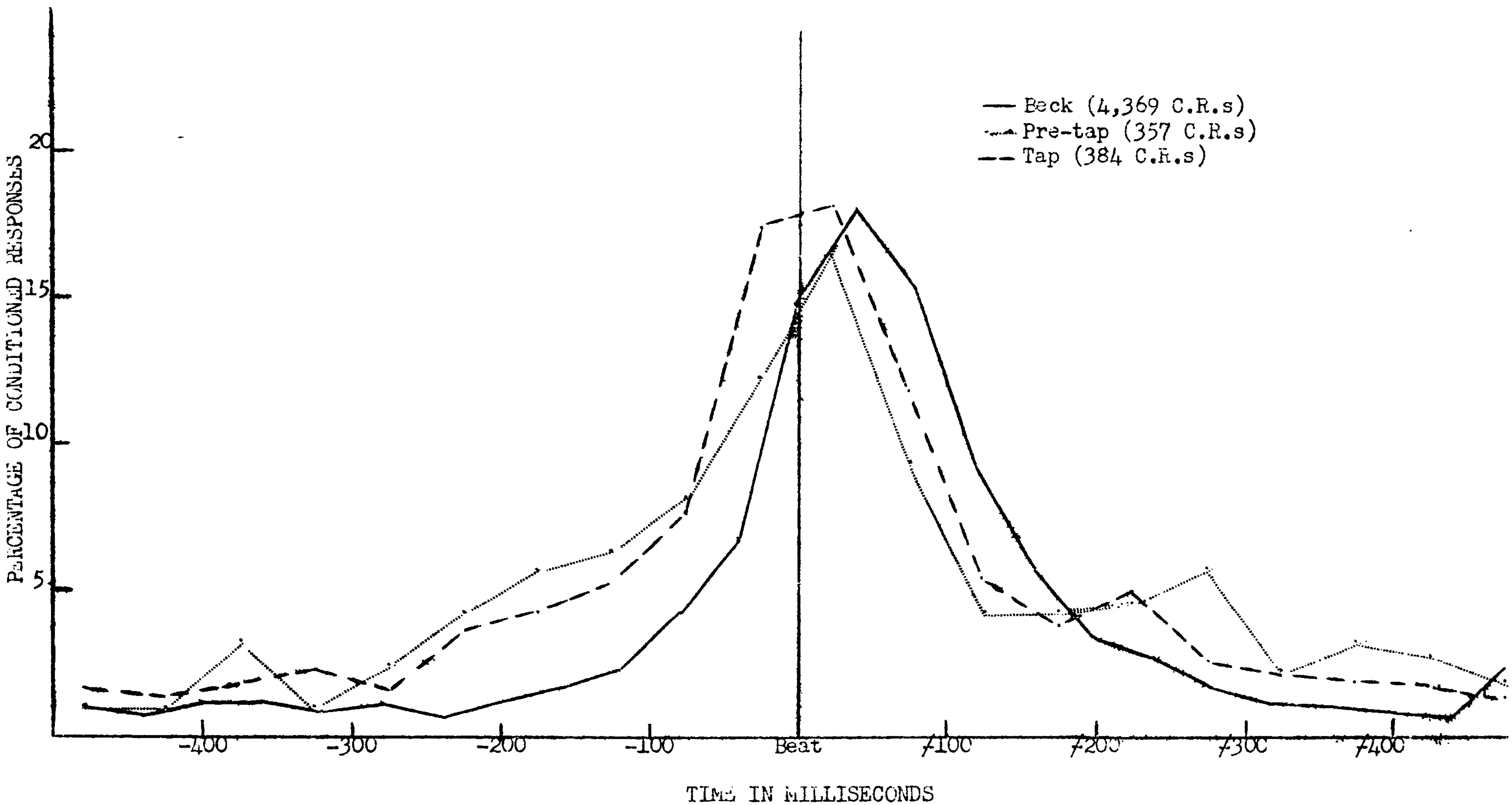

Fig. 5. The temporal distribution of conditioned responses in relation to the beat stroke of the movement cycle for our tap and pre-tap group and for Beck's pre-tap group.

TABLE 3

THE PERCENTAGE OF SUBJECTS WHO CONTINUED TO TAP AT LEAST ONCE UPON OMISSION OF THE BUZZER DURING INTERVALS BETWEEN TRIAL BLOCKS

		Group: Tap	Group: Pre-tap
Interval	1	77	86
	2	62	93
	3	85	86

for this is contained in table 3. When the buzzer was omitted during the intervals between trial blocks, the tap group showed almost as strong a tendency to continue tapping as did the pre-tap group.

It would be reasonable to assume that some of the clustering of CR's is caused not by the proprioceptive feedback but by the buzzer. On the average the beat-stroke was simultaneous with the buzzer onset with the median beat stroke latency within 10 milliseconds of the buzzer onset for both groups. However, the CR's of the no-tap group (Fig. 6) show no tendency to cluster when the buzzer was unaccompanied by consistent proprioception. The conclusion is that, in this case, the occurence of the beat stroke is the controlling influence necessary for CR clustering. This does not rule out the possibility that the buzzer, although not sufficient in itself, becomes part of a controlling stimulus pattern.

DISCUSSION

The above experiment may be taken as a demonstration of a habit under proprioceptive control. The presence or absence of a movement cycle controls the degree of stability of the learning. Moreover the pattern of movement feedback determines where the CR's will fall in respect to the temporal position of the CS and US. The relatively flat nature of the distribution of CR's for the no-tap group shows that responses do not become attached to any single aspect of the stimulus situation when there is no consistently recurrent proprioception.

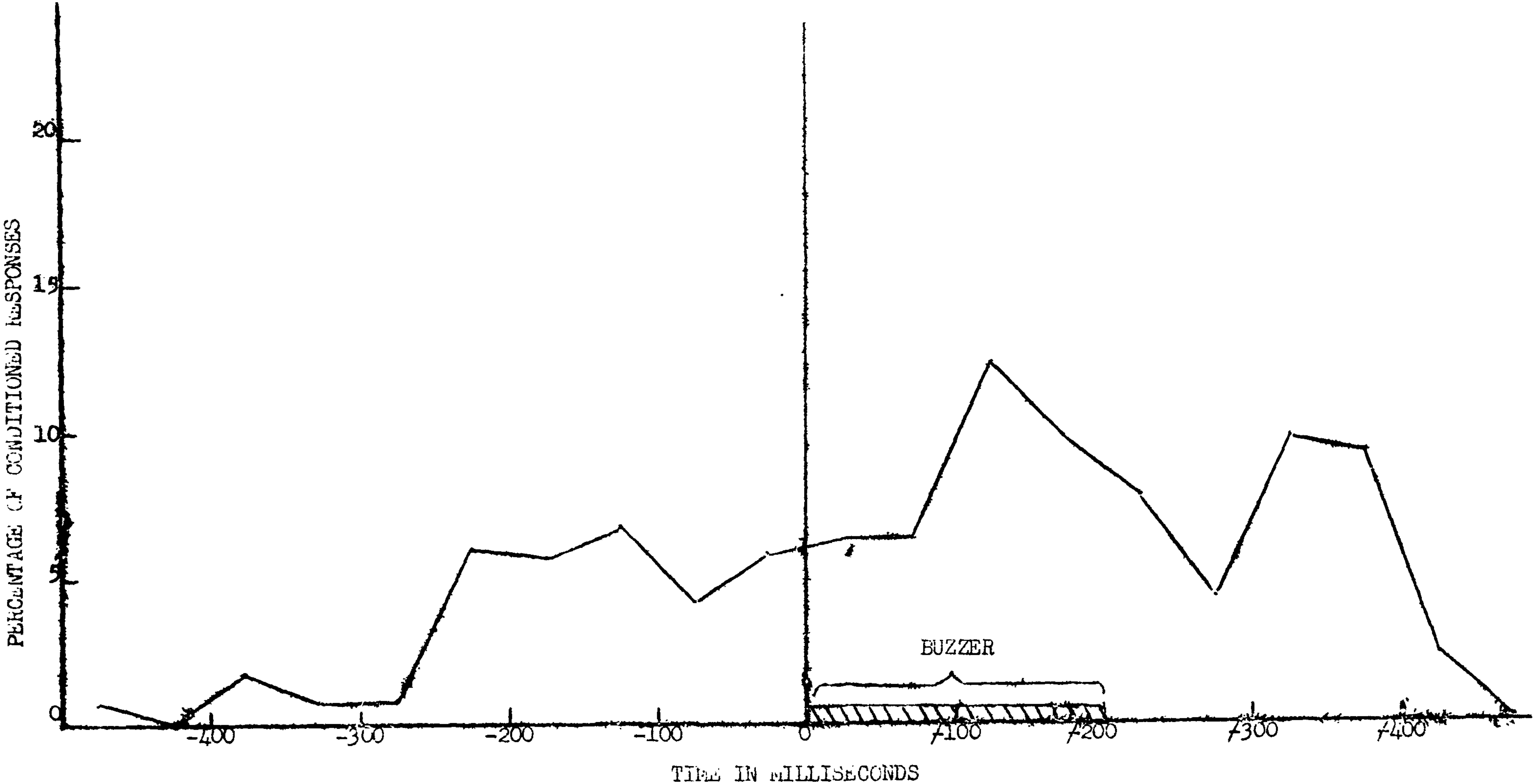

Fig. 6. The temporal distribution of conditioned responses in relation to the buzzer onset for the no-tap group (268 CR's)

With the proprioceptive control of habit graphically demonstrated, the next step was to manipulate some of the variables involved. One of the most obvious of these variables was the relationship between the beat-stroke of the movement cycle and the temporal position of the CS and US. The question involved was whether one particular phase of the movement cycle such as the beat-stroke was relatively more potent in its control of habit than other phases. An alternative explanation of the clustering of CRs is that the beat stroke happened to be the part of the movement cycle which coincided with the buzzer and that the consequent pattern of an external cue and internal feedback was the necessary and sufficient stimulus for response control. A test of these alternatives would be provided by separating in time the buzzer and the beat-stroke. Beck had found that the beat stroke was still the center of CR clustering when the temporal position of the click CS was systematically varied in respect to the US. It was our intention to see if the beat stroke would continue to attract responses if it was varied independently of the external CS. Accordingly we instructed a group of subjects (up-tap group) to raise a finger at the onset of the buzzer and then to immediately lower it to the table. It was hoped that this would have the effect of increasing the latency of the beat-stroke in respect to the buzzer onset thereby separating in time the beat and the buzzer.

Another method of variation of the timing of the movement cycle was attempted with subjects (puff-tap group) who were told to tap in time with the air puff. If the beat stroke is the crucial factor, then there should be a clustering of CR's adjacent to the puff. This condition was singular in that no particular phase of the movement cycle, either beat or up-stroke, was connected to the buzzer in the instructions to the subjects. Therefore we have a test of the possibility that set or the focusing of attention by instructions may help to determine what aspect of the stimulus situation achieves control over the conditioned response.

Data obtained from the up-tap and puff-tap groups are now being analyzed and will be described in a future report.

In research currently being conducted, the source of the proprioceptive feedback is being varied. Instead of manual movements the attempt is being made to use verbal responses as a source of proprioceptive control.. In one section of the experiment subjects will be required to repeat a nonsense syllable on each trial. It may prove to be the case that the feedback from the muscle movements involved in speech can serve to coordinate the conditioned response. Such a finding would assume theoretical importance in the light of the speculation in modern behavior theory over the complex role played by verbal responses. This is an attempt to see if speech movement proprioception obeys some of the same laws as the relatively grosser muscle movement feedback.

A related problem also being examined is the function of covert verbal response. J. B. Watson (3), among others, has advanced the theory that thinking involves covert movements of the vocal cords. In order to test this assumption we are trying to induce subjects to make repetitive thinking responses during training trials. If the motor theory of thought is correct, minute vocal cord movements are occurring on each trial and feedback from such movements might affect response in the same manner as overt verbalizations or hand movements.

The results of the experimentation with speech movements will be reported upon the completion of the relevant research.

SUMMARY

An eyelid conditioning procedure was applied to three groups of subjects. Of the three groups, one (pre-tap) had organized a movement cycle previous to training, a second (tap) made identical repetitive movements during training but had no previous practice, and the third (no-tap) made no consistent overt movements. Conditioning was obtained in all three groups but learning was more stable when consistent proprioceptive feedback was present. The CR's of the pre-tap and tap group became highly synchronized with the beat-stroke of the movement cycle. The results are interpreted as indicative of a habit under proprioceptive control. Variation of the time relationship between internal and external cues is described. Current research in which overt and covert speech movements are used as the source of proprioception is discussed.

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